4 Physical chemistry

Charges, chemical formulae and equations

Question	Answers and guidance	Marks
1 a)	$2CuCO_3(s) + C(s) \rightarrow 2Cu(s) + 3CO_2(g)$ 1 mark for correct formulae; 1 mark for correct balancing	2
b)	63.5 + 12 + 16 + 16 + 16 = 123.5	1 1
c) i)	Solid	1
ii)	$\frac{3}{2}$ = 1.5 mol	 1
iii)	12 + 16 + 16 = 44 44 × 1.5 = 66 g	1 1 1
Total		**9**

Question	Answers and guidance	Marks
2 a)	The (aq) symbol	1
b)	2 moles	1
c)	$2NH_3$ make 1 $(NH_4)_2SO_4(aq)$ so volume needed is 24 000 × 2 = 48 000 cm^3	1 1
d) i)	14 + 1 + 1 + 1 = 17	1 1
ii)	(18 × 2) + 32 + 16 + 16 + 16 + 16 = 132	1 1
e)	Filter the solution Dry on bench/in oven	1 1
Total		**10**

Question	Answers and guidance	Marks
3 a)	Filter the solution Wash the barium sulfate with water	1 1
b)	137 + 32 + 16 + 16 + 16 + 16 = 233	1 1
c)	233 × 0.25 = 58.25 g	1 1
d)	$\frac{36.12}{58.25} \times 100$ = 62%	1 1
e)	Barium sulfate is insoluble so no barium ions can enter the body/cells	1 1
Total		**10**

Question	Answers and guidance	Marks
4 a)	Exothermic (reactions)	1
b)	$CaO(s) + H_2O(l) \rightarrow$ **$Ca(OH)_2(aq)$**	1
c)	40 + 16 = 56	1 1
d) i)	$\frac{3.5}{56}$ = 0.0625 mol	1 1
ii)	0.0625 mol OR same figure as in d) i)	1
e)	$\frac{0.0455}{0.0625} \times 100$ = 72.8%	1 1
Total		**9**

Question	Answers and guidance	Marks
5 a)	Sulfur	1
b) i)	23 + 23 + 32 + 32 + 16 + 16 + 16 = 158	1 1
ii)	$\frac{1.58}{158}$ = 0.01 mol	1 1
iii)	0.01 moles OR the same as value in b) ii)	1
c)	24 000 × 0.01 = 240 cm^3	1 1
Total		**8**

Question	Answers and guidance	Marks
6 a)	Blue	1
b)	5 mol	1
c)	63.5 + 32 + 16 + 16 + 16 + 16 + [5 × (1 + 1 + 16)] = 249.5 g	1 1
d)	The reactants can become products and the products can change back to reactants	1
e)	The ⇌ symbol	1
Total		**6**

Practical work 1

Question	Answers and guidance	Marks
1 a)	Filter the solution	1
b)	Add equal quantities of indicator to three test tubes Add an acid to one, an alkali to the second and water to the third Record the colours seen in each test tube	1 1 1
c)	1 mark for each correct vertical column.	4
d)	Dip piece of universal indicator paper in each liquid Check against a pH chart to find the pH	1 1
Total		**10**

Colour of indicator	**red**	**yellow**	**green**	blue	**purple**
pH	**0**	**5**	**7**	**9**	**14**
Strength of acid/ alkali	**strong acid**	**weak acid**	**neutral**	weak alkali	**strong alkali**

Question	Answers and guidance	Marks
2 a) i)	It is an alkali	1
ii)	NH_4^+ and OH^-	1 1
iii)	OH^-	1
b) i)	It is an acid	1
ii)	Hydrochloric acid	1
iii)	H^+ and Cl^-	1 1
iv)	Hydrogen ion/H^+ ion	1
c) i)	Add universal indicator paper/solution It will turn green if neutral	1 1
ii)	A solution that is not acid or alkali/solution with pH 7	1
iii)	Ammonium chloride Water	1 1
Total		**14**

Question	Answers and guidance				Marks
3 a)	1 mark for each correct indicator				
	Indicator	**Colour of indicator in**			
		Acidic solutions	**Neutral solutions**	**Alkaline solutions**	
	methyl orange	red	yellow	yellow	1
	phenolphthalein	colourless	colourless	pink/lilac	1
	litmus	red	red or blue/purple	blue	1
b)	Phenolphthalein It changes colour from neutral to alkali				1 1
c)	Methyl orange It is the only indicator that changes colour from acid to neutral				1 1
d) i)	Dip piece of universal indicator paper in the solution It should turn green				1 1
ii)	One that is neither acid nor alkali				1
iii)	$H^+ + OH^- \rightarrow H_2O(l)$				1
Total					**11**

Question	Answers and guidance	Marks
4 a) i)	Solution turns green Magnesium oxide gets smaller/dissolves/disappears	1 1
ii)	Solution turns green Bubbles of gas Calcium carbonate gets smaller/dissolves/disappears	1 1 1
b)	Put a lighted spill in the gas. It will burn with a 'pop'	1
c) i)	Magnesium sulfate Water	1 1
ii)	Calcium nitrate Water Carbon dioxide	1 1 1
iii)	Magnesium chloride Hydrogen	1 1
d) i)	Calcium carbonate and nitric acid Shows two decimal places not one	1 1
ii)	Hydrochloric acid The pH was still less than 7/solution still acidic at the end	1 1
Total		**17**

Question	Answers and guidance	Marks
5 a)	Hydrochloric acid	1
b)	A layer of calcium sulfate formed Which is insoluble Preventing the acid reaching unreacted calcium carbonate	1 1 1
c)	Bubble gas through limewater It will go cloudy white/white precipitate/white suspension	1 1
d) i)	Collect the gas in a measuring cylinder/burette/graduated tube	1
ii)	Stopwatch/timer/clock	1
Total		**8**

Practical work 2

Question	Answers and guidance	Marks
1 a)	Warm the sulfuric acid with copper oxide Add more copper oxide until no more will dissolve Filter the solution Evaporate to obtain crystals	1 1 1 1
b)	Filter the crystals Dry by patting with filter paper/place crystals in warm oven	1 1
c)	Dissolve crystals in water Add some dilute hydrochloric acid and barium chloride solution A white precipitate should be formed	1 1 1
Total		**9**

Question	Answers and guidance	Marks
2 a)	A solid that appears in a liquid as a result of a chemical reaction	1
b)	Mix sodium sulfate and calcium nitrate solutions Filter the solution Wash the solid with water Dry the solid	1 1 1 1
c) i)	More than enough to complete the reaction	1
ii)	0.01 mol	1
iii)	0.02 mol	1
iv)	Formula mass of $CaSO_4$ = 40 + 32 + 16 + 16 + 16 + 16 = 136 136 × 0.01 = 1.36 g	1 1 1
d)	$\frac{0.95}{1.36} \times 100$ = 69.9%	1 1
Total		**13**

Question	Answers and guidance	Marks
3 a)	Hydrochloric acid	1
b)	Add the zinc oxide in warm hydrochloric acid until no more will dissolve Filter the mixture Evaporate the solution until one-third remains Filter the zinc chloride crystals and wash with water Dry the damp crystals	1 1 1 1 1
c)	$ZnO(s) + 2HCl(aq) \rightarrow ZnCl_2 + H_2O(l)$ 1 mark for correct formulae; 1 mark for correct balancing	1 1
Total		**8**

Question	Answers and guidance	Marks
4 a)	Sulfuric acid	1
b)	Too much sodium hydroxide had been added It hadn't all reacted So crystals of sodium hydroxide had formed with the sodium sulfate crystals	1 1 1
c)	Add the sodium hydroxide solution a little at a time After each addition test the solution with an indicator until it was neutral	1 1
d)	$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$ 1 mark for correct formulae; 1 mark for correct balancing	1 1
Total		**8**

Question	Answers and guidance	Marks
5 a) i)	Method 2 Copper sulfate is soluble	1 1
ii)	Copper oxide/carbonate Sulfuric acid	1 1
b) i)	Method 1 It is the only method that uses an alkali	1 1
ii)	Potassium hydroxide Hydrochloric acid	1 1
c) i)	Method 3 Lead iodide is insoluble	1 1
ii)	Lead nitrate Any named soluble iodide, e.g. sodium iodide	1 1
d)	All nitrates are soluble So they cannot precipitate out of a solution	1 1
Total		**14**

Question	Answers and guidance	Marks
6 a)	Any **two** problems with paired improvements; 1 mark for problem, 1 mark for improvement • Wrong acid – should use hydrochloric acid • Needs to check neutral solution obtained – add more nickel oxide until no more will dissolve/check pH of solution, add more nickel oxide until pH is 7 • Evaporate to dryness – should crystallise the solution rather than oven dry	4
b)	Dissolve crystals in water Add some dilute nitric acid and silver nitrate solution A white precipitate should be formed	1 1 1
Total		**7**

Data analysis

Question	Answers and guidance	Marks
1 a)	A catalyst	1
b)	More oxygen gas is produced with 1 g of manganese oxide at a faster rate	1 1
c)	There is no difference Both amounts produce nearly the same volume after the same time	1 1
d)	Using manganese(IV) oxide will increase the rate of the reaction The mass used does not make a difference	1 1
Total		**7**

Question	Answers and guidance	Marks
2 a)	A reaction where the reactants are turning into products and the products are turning back to reactants at the same rate	1 1
b)	Reduces the percentage of ammonia made	1
c)	To speed the reaction up	1
d)	After the same time with a catalyst there is more ammonia made This happens at every temperature	1 1
e) i)	More ammonia molecules are made	1
ii)	Fewer ammonia molecules are made	1
iii)	More ammonia will be made	1
Total		**9**

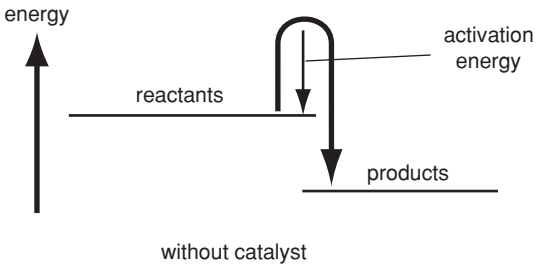
Question	Answers and guidance	Marks
3 a)	Increasing the temperature reduces the amount of sulfur trioxide made	1
b)	Reaction is exothermic As raising temperature decreases product	1 1
c)	It makes the reaction happen quicker	1
d)	Making more product would reduce the number of molecules from 3 reacting molecules to 2 product molecules	1 1
e)	Add a catalyst This would increase the rate, but not affect the amount of product made	1 1
Total		**8**

Question	Answers and guidance	Marks
4 a)	It is a reversible reaction	1
b)	Increasing the pressure increases the percentage of ammonia made Making more ammonia reduces the number of molecules in the equilibrium	1 1
c)	More ammonia will be made Reducing the temperature of an exothermic reaction will produce more products	1 1
d)	The high temperature may not speed up the reaction enough Adding a catalyst will make the reaction happen even quicker	1 1
Total		**7**

Working with graphs

Question	Answers and guidance	Marks
1 a)	The hydrochloric acid has all reacted So the reaction has finished at the maximum	1 1
b)	A It has the steepest curve/reaches the maximum first.	1 1
c)	C or D The graph is lower/less steep than graph B	1 1
d)	D It has not produced the maximum volume of carbon dioxide/it has not reached a plateau	1 1
Total		**8**

Question	Answers and guidance	Marks
2 a)	So she could tell if the line should be a straight line or a curve	1
b)	Increasing the temperature increase the rate	1
c)	An explanation linking the following points: • increasing the temperature increases the speed of particles • so they will collide more frequently • increasing the rate of reacting collisions	 1 1 1
d)	90	1
e) i)	30 s	1
ii)	An explanation linking the following points: • there will be twice as many particles on the surface • so there will be twice the number of collisions	 1 1
Total		**9**

Question	Answers and guidance	Marks
3 a)	To act as a catalyst Making the reaction go faster	1 1
b)	An explanation linking the following points: • more hydrogen gas is produced • the reaction finishes at 80 s/faster/sooner	 1 1
c)		1
d)	Amount of energy that must be given to a particle/reaction before it will react	1 1
e)	The catalyst lowers the activation energy	1
f)	An explanation linking the following points: • if the activation energy is lower • more particles will have the energy needed to react • so more of the collisions will produce reactions	 1 1 1
Total		**11**

Question	Answers and guidance	Marks
4 a)	More than enough of the chemical to make the other substance completely react	1
b) i)	A The chips reacted faster	1 1
ii)	An explanation linking the following points • increasing the surface area allows more particle to be exposed • so there will be more particles available to react • so there will be more reacting collisions	 1 1 1
c)	0.36 or 0.37 g	1
d) i)	A	1
ii)	An explanation linking the following points: • the curve/line has flattened out at the top • this shows that the reaction has finished	 1 1
iii)	240 s	1
Total		**11**

Question	Answers and guidance	Marks
5 a)	You need more than three points to show if the line should be a straight line or a curve	1 1
b)	0.25, 0.6, 1.23 mol/dm^3	1
c)	The three points do not lie on a straight line so it is a line of best fit/trend line	1 1
d)	24 s	1
e)	Increasing the concentration decreases the time for the cross to disappear	1
f)	An explanation linking the following points: • increasing the concentration provides more particles • so there will be more particles available to react • so there will be more reacting collisions	 1 1 1
Total		**10**

Calculations 1

Question	Answers and guidance	Marks
1 a)	28 – 21 = 7 °C	1
b)	Heat energy = mass × specific heat capacity × temperature rise = 50 × 4.2 × 7 = 1470 J	1 1 1
c)	$\frac{1 \quad 25}{1000}$ = 0.025 mol	1 1
d)	$\frac{1470}{0.025}$ = 58 800 J	1 1
Total		**8**

Question	Answers and guidance	Marks
2 a)	$\frac{1.0}{65}$ = 0.015 mol	1 1
b)	Heat energy = mass × specific heat capacity × temperature rise = 20 × 4.2 × 8 = 672 J	1 1 1
c)	$\frac{672}{0.015}$ = 44 800 J	1 1
d)	0 or nothing	1
e)	$\frac{1.0}{24} = 0.042$ 20 × 4.2 × 15 = 1260 J So $\frac{1260}{0.04} = 31\ 500$ J	1 1 1
f)	Solution doesn't weigh 1 g per cm^3/test tube will absorb heat energy/losses of heat energy to environment	1
Total		**12**

Question	Answers and guidance	Marks
3 a)	Use heat shield(s)/put lid on beaker	1
b)	Heat energy = mass × specific heat capacity × temperature rise 0.1 kg × 4.2 × 5 = 2.1 kJ	1 1 1
c)	75.20 – 74.28 = 0.92 g $\frac{0.92}{46}$ = 0.02 mol	1 1
d)	$\frac{2.1}{0.02}$ = 105 kJ	1 1
e) i)	$2H_2O$ has 4 O-H bonds/(464 × 4) = 1856 kJ	1 1
ii)	4 H atoms make 2 H_2 molecules, so 436 × 2 = 872 2 O atoms make O_2 molecule, so 498 + 872 = 1370	1 1
iii)	1856 – 1370 = + 486 kJ	1
Total		**13**

Question	Answers and guidance	Marks
4 a)	Temperature goes down The reaction is endothermic	1 1
b)	11 – 19 = –8 °C	1
c)	Heat energy = mass × specific heat capacity × temperature rise 25 × 4.2 × –8 = –840 J	1 1 1
d)	$\frac{8}{80}$ = 0.1 mol	1 1
e)	$\frac{-1108.8}{0.1}$ = –11088 J	1 1
f)	The enthalpy change for the reaction is positive/the reaction is endothermic	1
Total		**11**

Question	Answers and guidance	Marks
5 a)	The enthalpy change for the reaction.	1
b)	Heat energy = mass × specific heat capacity × temperature rise 50 × 4.2 × 6 = 1260 J	1 1 1
c)	25/1000 = 0.025 mol 1260/0.025 = 50 400 J	1 1
d)	There were losses to the beaker There were losses to the surroundings	1 1
Total		**8**

Calculations 2

Question	Answers and guidance	Marks
1 a)	$\frac{0.100 \quad 23.5}{1000}$ = 2.35×10^{-3} or 0.00235 mol (answer is also acceptable with 2 significant figures, i.e. 0.0024 mol)	1 1
b)	0.0047 mol	1
c)	$\frac{0.0047 \quad 1000}{25}$ = 0.188 mol/dm^3	1 1
Total		**5**

Question	Answers and guidance		Marks
2 a)	burette reading at end in cm^3	26.05	1
	burette reading at start in cm^3	1.70	1
	volume of acid added in cm^3	24.35	1
b)	$0.200 \times \frac{25}{1000}$ = 0.005		1 1
c)	0.005		1
d)	$\frac{0.005 \quad 1000}{24.35}$ = 0.205		1 1
Total			**8**

Question	Answers and guidance	Marks
3 a)	Use an indicator The reaction is over when no more carbon dioxide gas is released	1 1
b)	Trial 1 It is too far from the other three/it is an outlier/it is not concordant	1 1
c)	$\frac{41.80 + 41.95 + 41.75}{3}$ $= 41.83\ cm^3$	1 1
d)	$\frac{0.1 \quad 41.83}{1000}$ $= 0.0042$ mol	1 1
e)	0.0021 (half answer to part d))	1
f)	$\frac{0.0021 \quad 1000}{25}$ $= 0.084\ mol/dm^3$	1 1
Total		**11**

Question	Answers and guidance	Marks
4 a)	To remove any traces of lead nitrate and water So only lead iodide is weighed	1 1
b)	$\frac{9.22}{461}$ $= 0.02$ mol	1 1
c)	$0.02 \times 2 = 0.04$ mol	1
d)	$\frac{0.04 \quad 1000}{25}$ $= 1.6\ mol/dm^3$	1 1
Total		**7**

Question	Answers and guidance	Marks
5 a)	Phenolphthalein OR methyl orange Lilac or purple in alkali, colourless in neutral OR yellow in alkali, orange in neutral (reason to match indicator)	1 1
b)	To see the colour change easily	1
c)	$1.5 \times \frac{40}{1000}$ $= 0.06$ mol	1 1
d)	$\frac{0.06}{2} = 0.03$ mol	1
e)	$\frac{0.03 \quad 1000}{29.85}$ $= 1.00\ mol/dm^3$	1 1
Total		**8**